E & A

U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN 444.

REMEDIES AND PREVENTIVES AGAINST MOSQUITOES.

IMP. BUREAU ENTOM.
Rec'd 11 JAN1918

BY

L. O. HOWARD, PH. D.,
Entomologist and Chief, Bureau of Entomology.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1917.

CONTENTS.

	Page.
Introduction	5
Protection from bites	5
Protective liquids	5
Screens and canopies	6
Screening breeding places	7
Smudges and fumigants	7
Pyrethrum powders	7
Mimms culicide	8
Sulphur dioxid	8
Other fumigants	8
Apparatus for catching adult mosquitoes	9
Remedies for mosquito bites	9
Abolition of breeding places	9
Drainage measures	13
Destruction of larvæ by treatment of breeding places	13
The practical use of natural enemies of mosquitoes	15
Deterrent trees and plants	15

REMEDIES AND PREVENTIVES AGAINST MOSQUITOES.

INTRODUCTION.

Since the discovery that mosquitoes are not only nuisances, but are also conveyers of malaria, yellow fever, filariasis, and dengue fever, a great deal of remedial work has been done by individuals and communities. Many remedies and plans of action have been tested on a large scale, and what follows is a summary of the results.

PROTECTION FROM BITES.

PROTECTIVE LIQUIDS.

Spirits of camphor rubbed upon the face and hands or a few drops on the pillow at night will keep mosquitoes away for a time, and this is also a well-known property of oil of pennyroyal. Neither of these substances is durable; that is to say, a single application will not last through the night. Oil of peppermint, lemon juice, and vinegar have all been recommended, while oil of tar has been used in regions where mosquitoes are especially abundant. Oil of citronella is one of the best substances to be used in this way. The odor is objectionable to some people, but not to many, and it is efficient in keeping away mosquitoes for several hours. The best mixture tried by the writer was sent to him by Mr. C. A. Nash, of New York, and is as follows:

Oil of citronella	1 ounce
Spirits of camphor	1 ounce
Oil of cedar	½ ounce

Ordinarily a few drops on a bath towel hung over the head of the bed will keep the common house mosquitoes away. Where they are very abundant and persistent a few drops rubbed on the face and hands will suffice. Even this mixture, however, loses its efficacy toward the close of a long night. It is the habit of the yellow-fever mosquito, *Aëdes* (*Stegomyia*) *calopus* Meig., to begin to bite at daylight. By that time the average person is sleeping very soundly, and the effects of the mixture will usually have largely passed away. It follows that in the Southern States where this mosquito occurs these protective mixtures are not supposed to be as effective as they are in the North. As a matter of fact, however, this last mixture, could

it be applied shortly before dawn, would be as effective as under other circumstances.

A mixture recommended by Mr. E. H. Gane, of New York, is as follows:

Castor oil	1 ounce
Alcohol	1 ounce
Oil of lavender	1 ounce

This mixture was prepared for the purpose of avoiding the odor of the oil of citronella.

Oscar Samostz, of Austin, Tex., recommends the following formula:

Oil of citronella	1 ounce
Liquid vaseline	4 ounces

This mixture greatly retards the evaporation of the oil of citronella. Mr. B. A. Reynolds has used successfully in New Orleans 20 minims of oil of citronella to the ounce of vaseline or lanolin.

A 5 per cent solution of sulphate of potash has been recommended, as also the oil of cassia. Pure kerosene has also been used extensively in the Philippines.

SCREENS AND CANOPIES.

Such obvious measures as the screening of houses, the use of netting for beds, and the wearing of veils and gloves after nightfall in badly infested regions need no detailed consideration. Screening of houses can not be too carefully done, and adjustable, folding, or sliding window and door screens seem never to be tight; even with well-fitted screens there are often opportunities for mosquitoes to enter; constant care and vigilance alone will prevent this. In certain seasons in mosquito regions mosquitoes will attempt to make their way through screens and are often able to do so. When they are very numerous wire screens should be painted lightly with kerosene or oil of citronella.

With bed canopies there should be ample material to admit of a perfect folding of the canopy under the mattress, and the greatest care should be taken to keep the fabric well mended. It often happens in mosquito regions that little care is taken of the bed nettings in the poorer hotels, and it is necessary for perfect protection that a traveler in the Southern States should carry with him a pocket "housewife" and should carefully examine his bed netting every night, prepared to mend all tears and expanded meshes. Veils and nettings for camping in the Tropics or other regions where mosquitoes abound are absolutely necessary. Light frames are made to fit helmetlike over the head and are covered with mosquito netting. Similar frames, readily folded into a compact form, are

made to form a bed covering at night, and every camping outfit for work in tropical or malarial regions should possess such framework and plenty of mosquito netting as an essential part of the outfit.

The size of the mesh in mosquito bars and window screens is important. Twenty meshes to the inch can be relied upon to keep mosquitoes out, but 15 to the inch admits some of them.

SCREENING BREEDING PLACES.

Where the rain-water supply is conserved in large tanks, as in cities in the Gulf States, screening is necessary and is now rather generally enforced. Rain-water barrels everywhere should be screened in the same way, except where fish are used to kill the early stages of mosquitoes. A cheap cover for a water barrel can be made by covering a large iron hoop with a piece of stout calico or sacking, free from holes, in such a manner that a good deal of sag is left in the material.

SMUDGES AND FUMIGANTS.

Anything that will make a dense smoke will drive away mosquitoes, and various smudges are used by campers. For household use a number of different substances have been tried.

PYRETHRUM POWDERS.

Pyrethrum powders, known to the trade as Dalmatian insect powder, Persian insect powder, buhach, and otherwise, are very effective when fresh and pure. Pure powders are the finely ground flower-heads of two species of composite plants of the genus *Pyrethrum*. The essential principle seems to be a volatile oil that disappears with age and exposure. Many powders for sale in the drug stores are apparently diluted by the grinding of stems as well as flower-heads and in other ways. These powders are not so effective as pure powders. Pyrethrum powders are usually used dry, and are puffed or blown into crevices frequented by insects, or puffed or blown into the air of a room in which there are mosquitoes. The burning of the powder in a room at night is common practice. The powder is heaped up in a little pyramid which is lighted at the top and burns slowly, giving out a dense and pungent smoke. Often the powder is moistened and molded roughly into small cones, and after drying it burns readily and perhaps with less waste than does the dry powder. Mosquitoes are stupefied by the smoke and fall to the floor, where they may be swept up and burned. With open windows and constant currents of fresh air this fumigation is not especially effective, and it is necessary, for protection, to sit in a cloud of smoke.

The powder may be placed upon a metal screen above the chimney of a kerosene lamp, with the result that the vapor of the volatile oil will be dissipated. This is said to be very effective. It is economical in powder, and the odor is slight. Another method of burning the powder is to puff it from an insufflator into a burning gas jet. In New Orleans it has been found that in order to thoroughly clear houses of mosquitoes pyrethrum must be burned at the rate of nearly 1 pound of powder to every 1,000 cubic feet of space.

MIMMS CULICIDE.

This mixture is made of equal parts by weight of carbolic acid crystals and gum camphor. The acid crystals are melted over a gentle heat and poured slowly over the gum, resulting in the absorption of the camphor and a final clear, somewhat volatile liquid with an agreeable odor. This liquid is permanent, and may be kept for some time in tight jars. Volatilize 3 ounces of this mixture over a lamp of some kind for every 1,000 cubic feet of space. A simple apparatus for doing this may be made from a section of stovepipe cut so as to have three legs and an outlet for draft, an alcohol lamp beneath and a flat-bottom basin on top. The substance is inflammable, but the vapor is not explosive. The vapor is not dangerous to human life except when very dense, but it produces a headache if too freely breathed. Rooms to be fumigated should be made as nearly air-tight as possible.

SULPHUR DIOXID.

Burning of sulphur, or lump sulphur, in a small pot, at the rate of 2 pounds of sulphur for each 1,000 cubic feet of space, is efficient against mosquitoes where fumigation in the case of possible disease-bearing mosquitoes is desired.

OTHER FUMIGANTS.

According to Dr. John B. Smith, powdered jimson weed (*Datura stramonium*) can be burned to advantage in houses. He recommends 8 ounces to fumigate 1,000 cubic feet of space. He states that it should be made up by the druggist into an amount with niter or saltpeter 1 part to 3 of Datura, so as to burn more freely. He states that the fumes are not poisonous to human beings, are not injurious to fabrics or to metals, and can be used with entire safety. He suggests that it be burned in a tin pan or on a shovel.

The burning of dried orange peel has been recommended as a deterrent against mosquitoes by a Japanese physician.

APPARATUS FOR CATCHING ADULT MOSQUITOES.

An interesting homemade apparatus in common use in many parts of the United States is very convenient and effective. It consists of a tin cup or a tin-can cover nailed to the end of a long stick in such a way that a spoonful or so of kerosene can be placed in the cup, which may then, by means of the stick, be pressed up to the ceiling so as to inclose one mosquito after another. When covered over in this way the captured mosquito will attempt to fly and be caught in the kerosene. By this method perhaps the majority of the mosquitoes in a given bedroom—certainly all of those resting on the ceiling—can be caught before one goes to bed.

Mr. H. Maxwell-Lefroy, of India, makes a trap consisting of a wooden box lined with dark-green baize and having a hinged door. The trap is 12 inches long, 12 inches broad, and 9 inches deep. A small hole, covered by a revolving piece of wood or metal, was prepared in the top of the box. Owing to the habit of mosquitoes to seek a cool, shady place in which to rest, such as a dark corner of the room or a book shelf, or something of that sort, they will enter the trap, which is put in the part of the room most frequented by mosquitoes, all other dark places being rendered uninhabitable so far as possible. They are driven out of book shelves with a duster or with tobacco smoke, and go into the desirable sleeping place for the day. The door is then closed and fastened, and into the small hole at the top of the box a teaspoonful or less of benzine is introduced. This kills all of the mosquitoes inside, and the box is then thoroughly aired and replaced. In this way Mr. Lefroy is very successful in catching mosquitoes. At one time he averaged 83 a day.

REMEDIES FOR MOSQUITO BITES.

The most satisfactory remedy known to the writer, from his personal experience, has been moist soap. Wet the end of a piece of ordinary toilet soap and rub it gently on the puncture, and the irritation will soon pass away. Others have enthusiastically recommended household ammonia, or alcohol, or glycerin. One correspondent marks the puncture with a lump of indigo; another with one of the naphthaline moth balls; another, iodin. Rev. R. W. Anderson, of Wando, S. C., states that he has found that by holding his hand to a hot lamp chimney the irritation of mosquito punctures will be relieved instantly.

ABOLITION OF BREEDING PLACES.

It has been found that, taking the group of mosquitoes as a whole, their breeding places are of the most diverse character. Some species, however, are restricted in the character of their breeding places.

Certain forms, for example, breed only in tree holes; others in accumulations of water in epiphytic plants; other species breed only in the crabholes on sea beaches. Others are of more general breeding habits and will live in almost any chance accumulation of water. Certain species breed only in the salt marshes and lay their eggs on mud. Others lay their eggs upon the surface of water. Certain of the species in the more northern States breed only in the pools formed by melting snow, and as these occur at only one time of the year there is but one generation, and the eggs are laid in midsummer or later in such hollows in the earth as will be filled by the melting snow the ensuing spring. Another species, which is frequently very annoying, breeds only in certain permanent swamps, where the larva lives attached to the roots of certain aquatic plants. Still another breeds in the pitchers of pitcher plants (Sarracenia).

Culex pipiens L. in the North and *Culex quinquefasciatus* Say and (*Stegomyia*) *Aëdes calopus* Meig. in the South, however, breed in every chance receptacle of water about residences, and their destruction means the abolition or treatment of all such receptacles.

Where the rain-water barrel and rain-water tank are necessary they should be screened. About a given house the waste places in the immediate vicinity should be carefully searched for tin cans, bottles, and wooden or tin boxes in which water can accumulate and all such receptacles should be destroyed or carried away. The roof gutters of every building should be carefully examined to make sure that they are not clogged so as to allow the water to accumulate. Where the branches of tall trees overhang roofs this is especially likely to occur by the agency of falling leaves or twigs. The chicken pans in the poultry yard, the water in the troughs for domestic animals, the water cup of the grindstone are all places in which these mosquitoes will breed and water should not be allowed to stand in them for more than a day or so at a time.

In the South the water accumulating under water tanks should be treated or drained away. The urns in the cemeteries in New Orleans have been found to breed mosquitoes abundantly. The holy-water fonts in churches, especially in the South, have been found to breed mosquitoes abundantly. In slightly marshy ground a favorite breeding place is the footprints of cattle and horses. In one country village, which contained many small vegetable gardens in clay soil, during a rainy season mosquitoes were found breeding abundantly in the water accumulating in the furrows in the gardens.

Even in the house these mosquitoes breed in many places where they may be overlooked. Where the water in flower vases is not frequently changed mosquitoes will breed. They will breed in

water pitchers in unused guest rooms. They will breed in the tanks in the water-closets when these are not frequently in use. They will breed in pipes and under stationary washstands where these are not frequently in use, and they will issue from the sewer traps in back yards of city houses during dry spells in the summer time when the sewers have not recently been flushed by heavy rains. In warehouses and on docks they breed abundantly in the fire buckets and in water barrels. Of course such places as these can not be abolished, but should be treated in accordance with measures indicated in another section of this bulletin.

In country houses in the South, where ants are troublesome, and where it is the custom to insulate the legs of tables with small cups of water, mosquitoes will breed in these cups unless a small quantity of kerosene is poured in. Where broken bottles are placed upon a stone wall, water accumulates in the bottle fragments after rains, and mosquitoes will breed there.

Old, disused wells in gardens are frequent sources of mosquito supply, even where apparently carefully covered, and here the nuisance is easily abated by the occasional application of kerosene. The same thing may be said of cesspools. Cesspools are frequently covered with stone and cement, but the slightest break in the cement, the slightest crack, will allow the entrance of these minute insects, and unlimited breeding often goes on in these pools without a suspicion of the cause of the abundance of mosquitoes in the neighborhood.

Fountains and ornamental ponds are frequent breeding places, and here the introduction of fish, as indicated in another place, is usually all-sufficient. It frequently happens, however, that the grass is allowed to grow down into the edges of ornamental ponds and mosquito larvæ find refuge among the vegetation and so escape the fish. Broad-leaved water plants are also often grown in such ponds, and where these broad leaves lie flat on the surface of the water, as they frequently do, one portion of a given leaf may be submerged so that mosquito larvæ may breed freely in the water above the submerged portion of the leaf, protected from the fish by the leaf itself, the fish rising from below. It is necessary, therefore, to keep the edges of such ornamental ponds free from vegetation, and to choose aquatic plants whose growth will not permit of mosquito-larvæ protection.

In these latter localities not only the house mosquitoes, previously mentioned, or the rain-water barrel mosquitoes will be found, but also some of the other forms, and particularly the malaria-breeding mosquitoes of the genus Anopheles. Some of these breed in all sorts of water accumulations.

In many small country towns, even where there is a water supply, tanks are to be found under the roofs to supply bathrooms. Such tanks should be screened, since mosquitoes gain entrance to the tank room, either through dormer windows or by flying up through the house from below, in search of places to lay their eggs.

About a large old house or a public building there are so many of these chance breeding places that only the most careful and long-continued search will find them all. As an example, in a State hospital, after a search which lasted for many days, and after a treatment of all possible breeding places found, mosquitoes still continued to annoy the patients. Finally in the darkest part of a disused cellar was found a half-barrel with standing water in it, which was giving out mosquitoes at the rate of hundreds per day. Frequent change of water or the use of kerosene will render all such breeding places harmless.

In community work in cities all of the points mentioned must be borne in mind, and in the portions of the community where the residences are for the most part villas, in the absence of swampy suburbs the householders are in the main responsible for their own mosquitoes. There are, however, breeding places for which the municipality may be said to be responsible, and these entirely aside from public fountains, reservoirs, or marshes. Roadside open gutters or ditches may breed a generation of any one of several species of mosquitoes, including malarial mosquitoes. On a pasture or common, where sod has been removed, water accumulating in the excavation thus formed may breed a generation of malarial mosquitoes. All such accidental breeding places should be abolished by filling in.

It seems unlikely that in any general sewage system mosquitoes may breed in the sewers proper. That they do breed in the catch basins is well known. The purpose of the catch basin is to catch and retain by sedimentation sand and refuse which would otherwise enter the sewer and deposit in it. It is intended to be water tight and to hold a considerable body of water, which stands in it up to the level of the outlet pipe. Such catch basins are very commonly used in back yards and at the crossings of streets. The water is removed only by rain or when the street or yard surfaces are washed. In dry seasons the period of stagnation may last several weeks, certainly long enough for mosquito breeding. As a matter of fact mosquitoes in midsummer do breed in such traps or catch basins by millions. These basins may be treated with petroleum, or the municipal authorities may flush them once a week, carrying away such larvæ as may have hatched. Kerosene treatment, however, is best.

Public dumps are great breeding places, because here accumulate old bottles, cans, boxes, bits of tin or iron vessels, and other objects

in which water may accumulate for a time. Even a very small amount of water will make a breeding place for very many mosquitoes. It is quite possible for a half of a beer bottle to contain enough water to give out literally thousands of mosquitoes. The writer knows of one instance where a veritable plague of mosquitoes was traced to a case of empty beer bottles allowed to remain in a back yard for some weeks in midsummer.

There is a possibility that under certain circumstances mosquitoes may breed in water accumulating in the troughs of underground-conduit electric railways. There is abundant opportunity for water to accumulate in these troughs, but no exact observations upon mosquito breeding in such situations have been made.

Search carefully for all such places, and either abolish the standing water by carting away chance receptacles, by turning over vessels, by filling in excavations, or by treating other receptacles with a film of kerosene, or by introducing fish into fountains and artificial pools.

DRAINAGE MEASURES.

Drainage measures really form a part of the consideration of the treatment of breeding places. The drainage of swamp areas for agricultural or industrial reasons needs no argument. The value of reclaimed swamp land for various purposes is well known. The drainage of swamp areas primarily in order to improve sanitary conditions and to reduce the scourge of mosquitoes which in itself often prevents the proper development of nearby regions is in operation and needs no argument. Drainage on a small scale for the purpose of doing away with mosquitoes has been practiced for a long time, and in many parts of the country large-scale drainage with mosquito abolition in view is going on, notably in New Jersey and in California. Methods of draining can not be entered into in this bulletin, but it should be pointed out that in case of salt-marsh land the operation is inexpensive, and results of great value have been reached both in California and in New Jersey.

DESTRUCTION OF LARVÆ BY TREATMENT OF BREEDING PLACES.

While it is obviously best to abolish breeding places in the ways mentioned, it often happens that it is not possible to drain, and at least as a temporary expedient it becomes desirable to treat the water so as to kill the mosquito larvæ. Many substances have been tried, and, aside from certain proprietary mixtures, nothing has given such good results as the use of oils. Efforts to find oils that can be used to better advantage than petroleum have failed. Common kerosene

of low grade, or of the grade known as fuel oil, is the most satisfactory as regards efficiency and price.

In choosing the grade of oil two factors are to be considered: First, it should spread rapidly; second, it should not evaporate too quickly. The heavier grades of oil will not spread readily over the surface of the water, but will cling together in spots and the coating will be unnecessarily thick. The rapidity of spread of the film is also important. As to quantity, under still conditions, an ounce of kerosene to 15 square feet of surface space is about the right proportion, and in the absence of wind such a film will remain persistent for 10 days or slightly longer. Even after the iridescent scum apparently disappears there is still an odor of kerosene about the water. In a wind the film of kerosene is frequently blown to one side, but with a change will go back again, so that larvæ are destroyed. Not only are larvæ and pupæ destroyed by the kerosene film, but many adult mosquitoes alighting on the surface of the water to drink or to lay their eggs are killed by it. In California, Mr. H. J. Quayle has used a combination of heavy oil of 18° gravity and a light oil of 34° gravity, in the proportion of 4 to 1, respectively. This mixture made an oil that was just thin enough to spray well from an ordinary spray nozzle and yet was thick enough to withstand very rapid evaporation. It was applied by a barrel pump where this could be used, and by an ordinary knapsack pump in other regions. A single application was found by Mr. Quayle to be effective sometimes up to four weeks. The army of occupation in Cuba used oil every two weeks.

The use of a spray pump has been mentioned. Small ponds can be sprinkled out of an ordinary watering pot with a rose nozzle, or for that matter pouring it out of a dipper or cup will be satisfactory. In larger ponds pumps with a straight nozzle may be used. A straight stream will sink and then rise and spread until the whole surface of the pond can be covered without waste. The English workers in Africa advise mopping the kerosene upon the surface of the water by means of cloths tied to the end of a long stick and saturated with kerosene.

In Panama a larvicide is being used which is made as follows: 150 gallons of carbolic acid is heated in a tank to a temperature of 212° F., then 150 pounds of powdered or finely broken resin is poured in. The mixture is kept at a temperature of 212° F. Thirty pounds of caustic soda is then added and the solution is kept at the same temperature until a perfectly dark emulsion without sediment is formed. The mixture is thoroughly stirred from the time the resin is used until the end. One part of this emulsion to 10,000 parts of water is said to kill Anopheles larvæ in less than half an hour, while 1 part to 5,000 parts of water will kill them in from 5 to 10

minutes. At a larvicide plant at Ancon 4,600 gallons of this mixture were made at a cost of $0.1416 per gallon. Although this mixture has been used to a large extent in Panama, crude oil was also used for streams having a fair velocity.

THE PRACTICAL USE OF NATURAL ENEMIES OF MOSQUITOES.

The common goldfish and silverfish destroy mosquito larvæ and should be put in artificial ponds. Top-minnows of several species have been introduced successfully in several localities and are great feeders upon mosquito larvæ. Certain species introduced from Texas into Hawaii have been successful; and a small top-minnow of the genus Girardinus, known in the Barbados as "millions," has been carried with success to others of the British West India Islands. In Rio de Janeiro another top-minnow has been used by the public health service for placing in tanks and boxes where it was impossible to use petroleum.

There are many predatory aquatic insects that feed upon mosquito larvæ; others that catch the adults. Certain birds prey upon the adults, and they are also eaten by bats. An experiment is being carried on near San Antonio, Tex., in which a bat roost has been constructed with the dual purpose of gathering the bats to kill mosquitoes of that region and of collecting the bat guano.

DETERRENT TREES AND PLANTS.

A great deal has been published concerning the properties of certain growing plants which are said to keep away mosquitoes. Among these may be mentioned several species of Eucalyptus, the castor-oil plant, the Chinaberry tree, and others. Although the evidence in regard to these plants is contradictory, all observations made by scientific men in different parts of the world negative their value; claims that they are valuable are confined to people who have not made thoroughly scientific tests.

444

O